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this source, influence and largely assume direction of our thought. But is not this source often poisoned, giving rise (as Freud, Jung, *et al.*, have shown *ad nauseam*) to unworthy prejudices, freakish and fallacious assumptions, idle fancies, and dangerous longings? On the other hand (2) the cool, intelligent weighing of evidence, the critical control of impulsive tendencies of all kinds until they have satisfied our tests for rationality—is not this also to be called "spontaneous," a matter of self-direction? Before the question, which of the two selves, (*a*) the instinctive, subconscious, animal self, or (*b*) the rational, critically self-conscious, human self, the logician should prefer, there can surely be no hesitation. All the armory of logic, its whole *raison d'être* as a philosophical discipline, is surely intended for one main purpose, and for one main purpose alone: to aid us in our fight for control over forces within as well as without, and to fit us for living the life of cool reason, the life of deliberate, self-knowing and self-directing activity, the life of idealized will rather than of brute instinct and mechanical habit, the life of the "higher" or rational self. The study of the obscure spirits which lurk in the subconscious, belongs, not to logic, but to psychology, and is relegated to that science by the unanimous voice of modern logicians.

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EDDINGTON ON EINSTEIN

LAST fall when the news that the British eclipse expeditions had confirmed Einstein's law of gravitation sent curious Americans scurrying to their Carnegies, they found that there was only one book in English giving an adequate account of the theory in its generalized form and that very few copies of this had come to America. This much demanded volume was Professor Eddington's *Report on the Relativity Theory of Gravitation* published by the Fleetway Press for the Physical Society of London in 1918. The Cambridge Professor of Astronomy was a member of the expedition which was sent to the island of Principe in the bight of Africa to observe the eclipse of May 29, for the express purpose of ascertaining if the deflection of starlight predicted by Einstein took place. The plates taken in Africa and South America showed a deviation of the images of seven stars corresponding closely with those calculated from the theory and when Professor Eddington and his associates so reported to the joint session of the Royal and Astronomical Societies on November 6 it was declared by the President to be "one of the most momentous, if not the most momentous, pronouncements of human thought." A month later Professor Eddington gave a talk at Trinity College and one might have thought that a new play was opening for the cue of dons and undergraduates stretched half way across the Great Court while inside the dining hall there was "standing room only." In our country we have the amazing spectacle of "Einstein books," published hastily to meet the popular demand, stacked up on the quick sales counter of the bookstore to an altitude comparable to that of the latest novel.

Professor Eddington, as the foremost champion of *Einsteinismus* in English is pre-eminently qualified to satisfy the curiosity of the general reader as well as the needs of the serious student and his latest book, *Space, Time, and Gravitation,*[1] is excellently adapted to serve both classes. He employs mathematical formulæ as far as necessary, yet the non-mathematical reader can pick his way through the volume, as on stepping stones across a creek, on the paragraphs of summary or illustration that he understands better or thinks he does. The author, unlike some authorities, does not shy off from the sensational aspects of the theory of relativity. On the contrary he obviously takes delight in playing up its paradoxes. Sir Oliver Lodge, who as an adherent of the ether is antagonistic to the new notions, said in discussing Professor Eddington's address before the Royal Astronomical Society that one of the things which astonished him most about it was that Professor Eddington thought that he understood it.

What particularly puzzled Sir Oliver Lodge was the proposed replacement of the straight line as the path of a freely moving body by the "geodesic" which is the longest distance between two points. As Professor Eddington expresses it in his lecture, the earth in passing from the point it occupied a hundred years ago to the point it occupies now might have done it in no time, as judged by those traveling on it. For the earth might have cruised around with the velocity of light and turned up at its present point with its clocks at the same hour and its people at the same age. "But the earth did not do that. It was bound by the rules and the rule of the great trade union of matter is that the longest possible time must be taken over any job." So the earth pursues a leisurely spiral—"a circle in space drawn out into a spiral by continuous displacement in time. Any other course would have had a shorter interval length" (page 72). Or to give the law of motion its general expression: "Every particle moves so as to take the track of

[1] Cambridge University Press, 1920.

greatest interval-length between two events, except in so far as it is disturbed by impacts of other particles or electrical forces.'' There are any number of ''shortest'' paths; there is only one of the maximum interval-length through time and space. Einstein deduces the laws of motion from his law of gravitation. In Newton's theory there is no apparent connection. Einstein deals solely with the *course* of a gravitating body; he is not concerned with a hypothetical ''force'' of gravitation. Gravitational force is no more ''real'' than centrifugal force, since either may be annulled by choosing a suitable standard observer.

The presence of matter in space necessitates a non-Euclidean geometry for its measurements. This curvature of the empty space of a gravitational field can be calculated and might be measured if our instruments were exact enough. For instance if a massive particle is placed at the center of a circle the ratio of the circumference to the diameter would be a little less than π. ''If the mass of a ton were placed inside a circle of 5 yards radius, the defect in the value of π would appear only in the twenty-fourth or twenty-fifth place of decimals'' (page 104).

Although this curvature or ''hummock'' produced by matter can not be measured directly, it can be found indirectly by observation of the path of a planet, or of a ray of light near the sun. The author sums up his exposition of gravitation in these words:

> The simplest type of hummock with this limited curvature has been investigated. It has a kind of infinite chimney at the summit, which we must suppose cut out and filled up with a region where this law is not obeyed, *i.e.*, with a particle of matter.
>
> The tracks of the geodesics on the hummock are such as to give a very close accordance with the tracks computed by Newton's law of gravitation. The slight differences from the Newtonian law have been experimentally verified by the motion of Mercury and the deflection of light.
>
> The hummock might more properly be described as a ridge extending linearly. Since the interval-length along it is real or time-like, the ridge can be taken as a time-direction. Matter has thus a continued existence in time. . . .
>
> The laws of conservation of energy and momentum in mechanics can be deduced from this law of world-curvature.[2]

The student of philosophy and psychology rather than of scientific methods will turn with most eagerness to the final chapter wherein Professor Eddington discusses the speculative aspects of the relative theory. He gives this chapter the Lucretian title: ''On the Nature of Things,'' and endeavors to forestall ridicule by quoting from *Midsummer Night's Dream:*

> *Hippolyta.* This is the silliest stuff that ever I heard.
>
> *Theseus.* The best in this kind are but shadows; and the worst are no worse, if imagination amend them.

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[2] P. 151.

Here is his idea of the trend of the relativity theory:

> This is how our theory now stands. We have a world of point-events with their primary interval-relations. Out of these an unlimited number of more complicated relations and qualities can be built up mathematically, describing various features of the state of the world. These exist in nature in the same sense as an unlimited number of walks exist on an open moor. But the existence is, as it were, latent unless some one gives a significance to the walk by following it; and in the same way the existence of any one of these qualities of the world only acquires significance above its fellows, if a mind singles it out for recognition. Mind filters out matter from the meaningless jumble of qualities, as the prism filters out the colors of the rainbow from the chaotic pulsations of white light. Mind exalts the permanent and ignores the transitory; and it appears from the mathematical study of relations that the only way in which mind can achieve her object is by picking out one particular quality as the permanent substance of the perceptual world, partitioning a perceptual time and space for it to be permanent in, and, as a necessary consequence of this Hobson's choice, the laws of gravitation and mechanics and geometry have to be obeyed. Is it too much to say that mind's search for permanence has created the world of physics? So that the world we perceive around us could scarcely have been other than it is? . . . The conclusion is that the whole of those laws of nature which have been woven into a unified scheme—mechanics, gravitation, electro-dynamics and optics—have their origin, not in any special mechanism of nature, but in the workings of the mind.
>
> ''Give me matter and motion,'' said Descartes, ''and I will construct the universe.'' The mind reverses this. ''Give me a world—a world in which there are relations—and I will construct matter and motion.'' . . .
>
> We have found a strange foot-print on the shores of the unknown. We have devised profound theories, one after another, to account for its origin. At last, we have succeeded in reconstructing the creature that made the foot-print. And lo! it is our own.[3]

Some mathematicians and physicists have manifested impatience at the impertinent curiosity of the public and declare that Einstein's theory concerns only themselves, and whatever they may decide to do with it can have no possible effect upon anybody's religion, philosophy or view of life. But the public knows better. And Professor Eddington agrees with the majority on this question. Galileo, Newton and Darwin were specialists, speculating in fields remote from common life, yet they have revolutionized the thought and altered the conduct of the world. Einstein's theory is even more fundamental and unconventional and if it is verified by experiment or genrally adopted as a working hypothesis it will be found in the course of time to have a profound influence upon the minds of men outside of the realm of science.

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[3] P. 201.